

PARMELA simulations of electron beam from the AWA gun with 1 nC charge

Haitao Wang, Wei Gai

High Energy Physics Division
ANL

Motivation: Simulate a beam from the new AWA gun and linac with 1 nC charge and achieve emittance on the order of ~ 1 mm-mrad using PARMELA.

PARMELA simulation:

We use the current AWA laser parameters of bunch length 8 ps FWHM, so it is assumed flat top bunch length of 2° and flat top transverse profile of 2 mm radius.

In Fig. 1, we show effect of the cathode electric field in the gun on the r.m.s. bunch length and emittance for 1 nC beam. Both emittance and bunch length decrease as the electric field increases. Fig. 2 shows the beam's energy and energy spread dependence on the cathode field. Fig. 3 shows the effect of cathode spot size on the r.m.s. bunch length and emittance for 1 nC beam when keeping the peak electric field on cathode surface constant ($= 100$ MV/m).

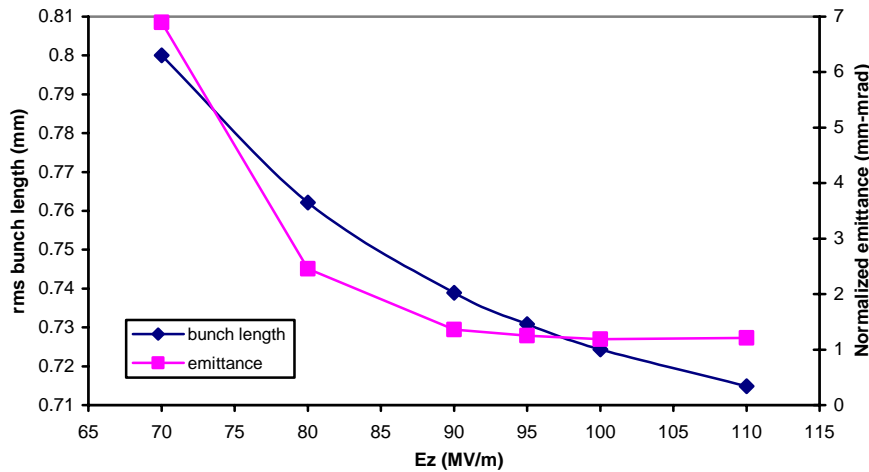


Fig. 1. Simulations of the electron bunch length and emittance dependent on the peak electric field on the photocathode.

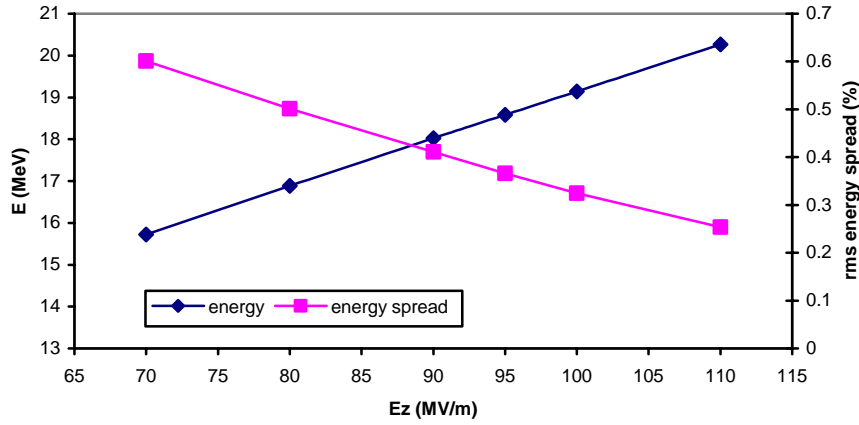


Fig. 2. Energy and energy spread of a 1nC beam at the end of Linac. It shows the trend that higher field on the cathode not only improves the bunch length and emittance, but also reduces the energy spread.

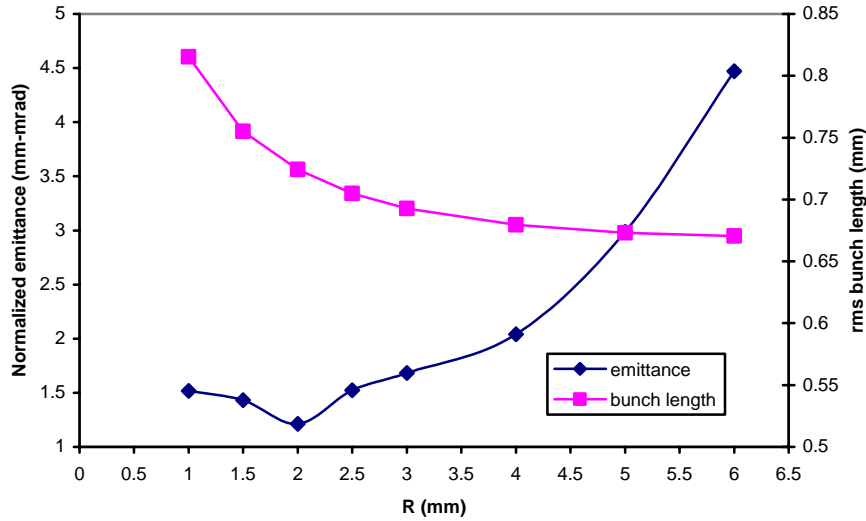


Fig. 3. The electron bunch length and emittance dependence on the radius of spot on the photocathode. The simulation uses 1nC charge and 100 MV/m peak electric field on the photocathode.

After carefully adjusting photocathode spot size, intensity of axial electric field on cathode surface, and currents of focus magnetic fields, we have obtained optimum emittance equals to 1.8 mm-mrad (100% particles), and 1.04 mm-mrad (90% particles). The detailed input parameters are listed as followed.

Radius of spot on the cathode = 2 mm,
 E_z (peak electric field on the photocathode surface) = 100 MV/m,
 Current of the 1st solenoid magnetic field = 10000 Amps,
 Current of the 2nd solenoid magnetic field = -10000 Amps,
 Current of the 3rd solenoid magnetic field = -34700 Amps.

Under these conditions, we obtain electron beam contour along the z-axis, shown in Fig. 4, evolution of the normalized transverse emittance in Fig. 5, and evolution of the r.m.s. bunch length in Fig. 6.

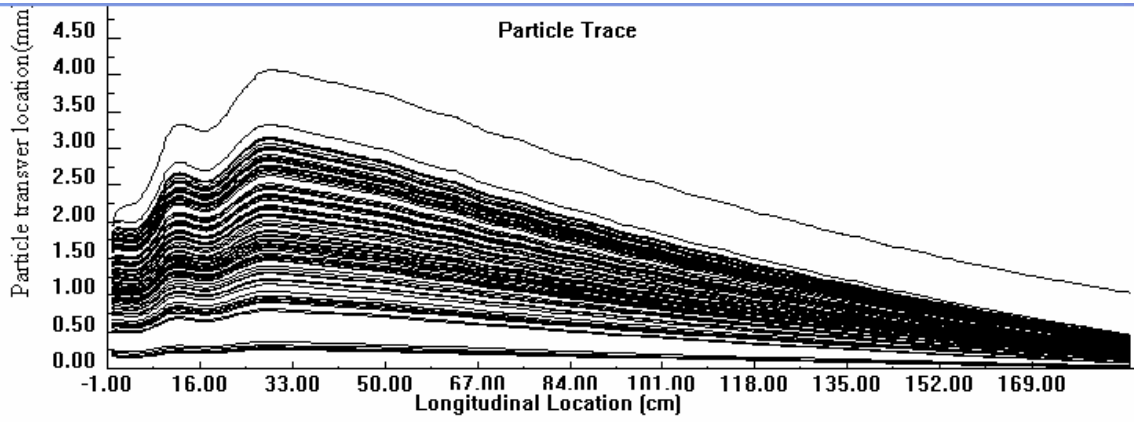


Fig. 4. $r - z$ traces of selected macro-particles in the both gun and linac for 1 nC beam.

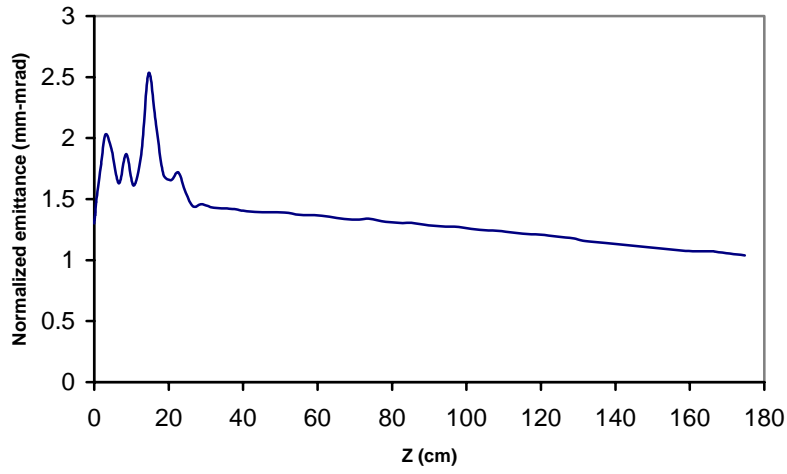


Fig. 5. Evolution of the normalized transverse emittance for the 1 nC beam along the z-axis.

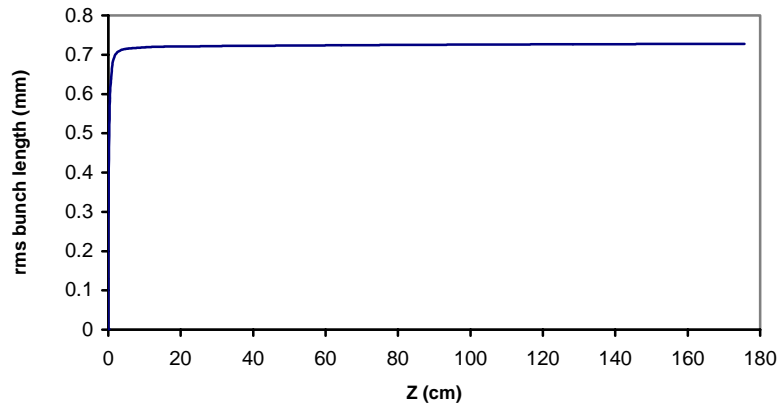


Fig. 6. Evolution of the r.m.s. bunch length for the 1nC beam along the z-axis.